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Title: Comparison of DDSI Experimental and Simulated Results

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Comparison of DDSI Experimental and Simulated Results

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PADGS

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LA-UR-XXXXXX

Summer Fun (Rio Grande Bridge on the way to Taos)

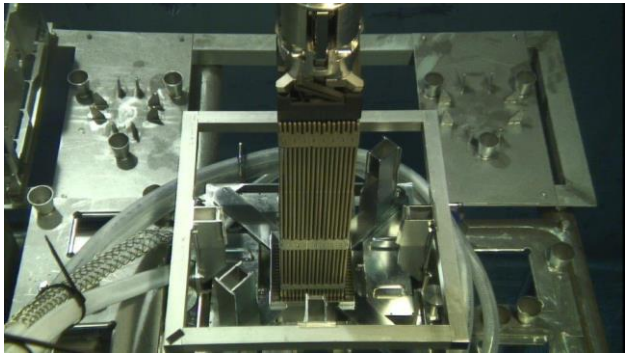
Amanda Youmans (NEN-1)

- Educational Background
  - BS Nuclear Engineering RPI, 2014
  - Current Nuclear Engineering PhD student at RPI

- PADGS
  - Nuclear Safeguards and Technology
  - Mentor: Alexis Trahan

- Research
  - Modeling DDSI and SKB50 spent fuel assemblies with MCNP6

Research Overview and Motivation



- **Safeguarding spent nuclear fuel**
  - Spent fuel contains reactor grade plutonium
  - Spent fuel is often stored on-site at nuclear power facilities
  - The IAEA is tasked with verifying that no SNM is misdirected
- **Existing technologies are inadequate for reliably determining if fuel pins have been diverted**
  - Fork detector (total gamma and neutron signals)
    - No coincidence, no measure of the fissile mass
    - Only observe gammas from the outside of the assembly (self-shielding)
  - Cherenkov cameras
    - Murky water, only see the top of the assemblies
    - Can only measure higher activity assemblies

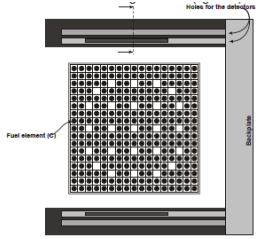


Figure 1. Horizontal cross-section of the FORK detector with a 17x17 PWR fuel assembly

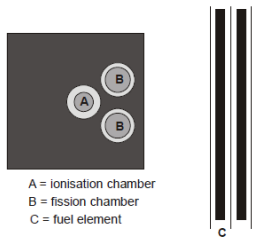
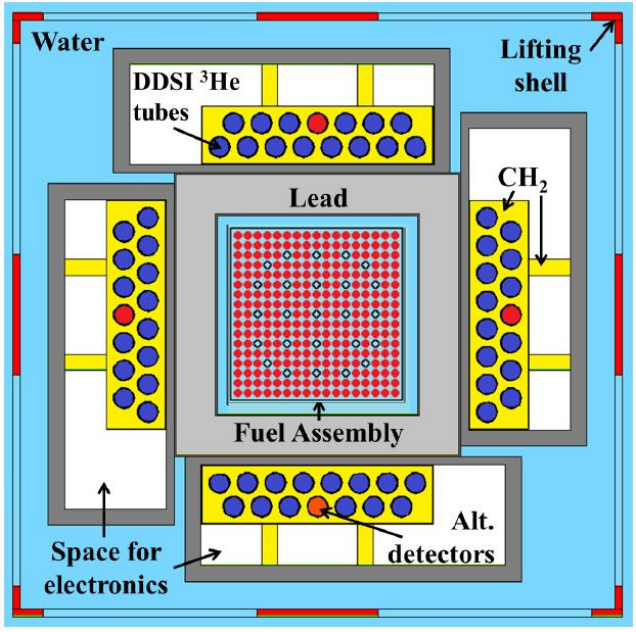


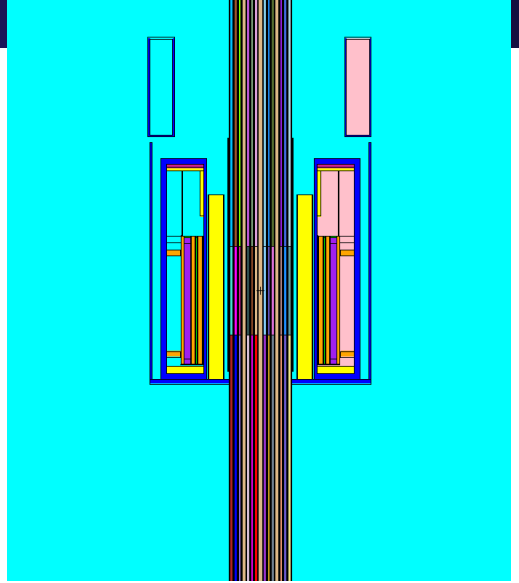
Figure 2. Vertical cross-section of an arm of the FORK detector, showing the position of the three detectors

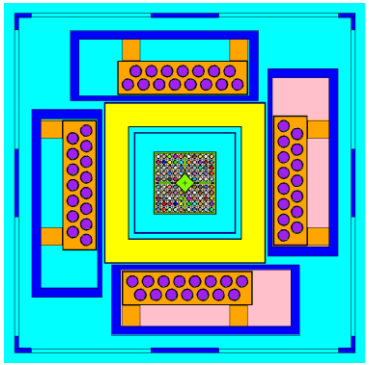
Research Approach: Modeling the Differential Die-away Self Interrogation (DDSI) Detector System

- **DDSI was developed at LANL and tested at Clab in Sweden on the SKB50 set of PWR and BWR spent fuel assemblies**
  - Passive Non-Destructive Assay tool
  - Well-known spent fuel assemblies used to benchmark the system
- **MCNP modeling of DDSI**
  - Used to better understand the system
    - Lower systematic uncertainties
    - Develop data analysis methods, eg. Correction factors
  - Sensitivity studies
    - Assembly position



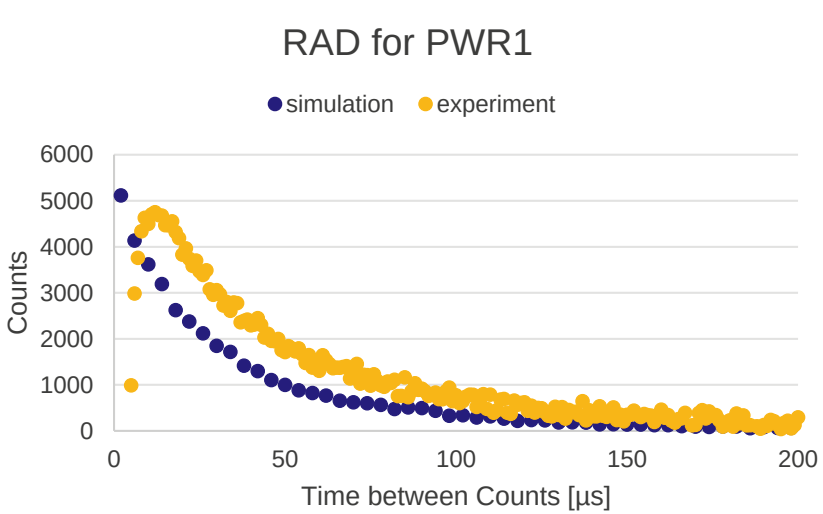
Summary of Results





- **Modeling of 25 PWR spent fuel assemblies in DDSI**
  - Singles, doubles rates
  - RAD
  - Die-away times
- **Modeling of 25 BWR spent fuel assemblies in DDSI**
  - Singles, doubles rates
  - RAD
  - Die-away times
- **Position sensitivity for PNAR analysis technique**
  - Ratios of singles rates in each detector between simulations with the detectors at different positions

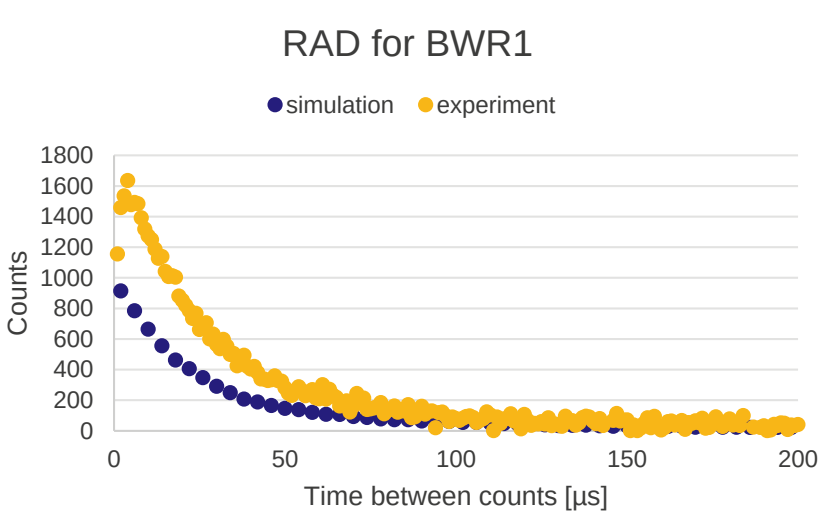
Modeling of PWR spent fuel assemblies in DDSI



	Fast Tau			Slow Tau		
PWR#	Sim [µs]	Exp [µs]	C/E	Sim [µs]	Exp [µs]	C/E
1	12.9	25.6	**0.505**	53.7	60.2	**0.892**
2	17.9	23.0	**0.778**	57.2	60.6	**0.943**
25 PWR avg.	--------	--------	**0.833 ± 0.129**	--------	--------	**0.857 ± 0.061**

	Singles Rate [cps]			Doubles Rate [cps]		
PWR #	simulation	experiment	C/E	simulation	experiment	C/E
1	5551482	3907930	**1.421**	242344	94186	**2.573**
2	4032254	3411292	**1.182**	179966	87284	**2.062**
3	3042818	2461852	**1.236**	131338	69334	**1.894**
25 PWR avg.	----------		**1.176 ± 0.114**	----------		**1.613 ± 0.319**

Modeling of BWR spent fuel assemblies in DDSI



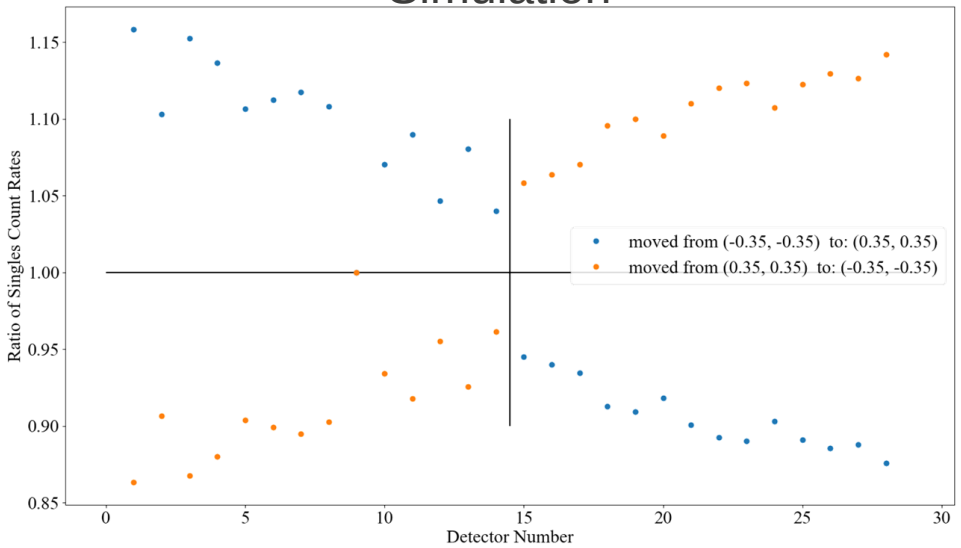
	Fast Tau			Slow Tau		
BWR#	Sim [µs]	Exp [µs]	C/E	Sim [µs]	Exp [µs]	C/E
1	14.260	18.142	**0.786**	83.182	61.525	**1.351**
2	18.218	17.045	**1.068**	86.160	54.515	**1.580**
25 BWR avg.	-------	-------	**0.979 ± 0.050**	-------	-------	**1.377 ± 0.110**

	Singles Rate [cps]			Doubles Rate [cps]		
BWR #	simulation	experiment	C/E	simulation	experiment	C/E
1	788270.5	1159563	**0.679**	11477.22	27324.75	**0.420**
2	715181.9	962173.6	**0.743**	11043.25	23054.76	**0.479**
3	499429.6	833822.9	**0.598**	7663.003	20715.96	**0.370**
25 BWR avg.	----------		**0.721 ± 0.093**	----------		**0.423 ± 0.078**

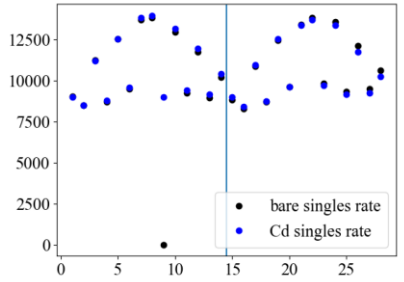
Position sensitivity for PNAR analysis technique

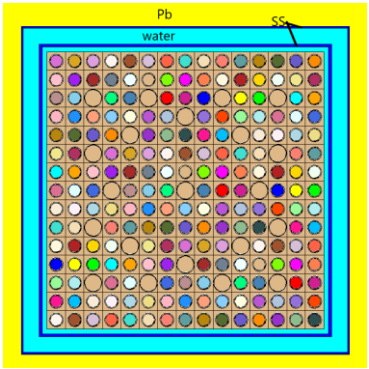
- **1 mm movements were modeled for PWR11 spent fuel assembly**
- **Position has a significant effect on the rates in each detector**
  - ±15% singles rate when moved the maximum of 7 mm in x and y directions

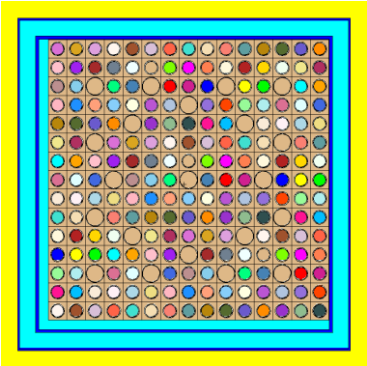
Simulation



Experiment







Conclusion

- **The End**
- **Any Questions?**